

Application Serial No.: 10/646,892  
Reply to Office Action dated July 28, 2005

REMARKS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-4 are presently active in this case, Claims 1, 3, and 4 having been amended by way of the present Amendment. Claims 3 and 4 have been rejoined.

The amendments set forth herein do not raise new issues on the merits of the application, but rather merely include the changes suggested in the outstanding Official Action.

The disclosure was objected to because of minor informalities. The specification, including the written description, abstract, and claims, has been amended as suggested pages 2-4 of the Official Action. Accordingly, the Applicant requests the withdrawal of the objection to the disclosure.

The Applicant has attached hereto a copy of the "Lecture Manuscripts" noted on page 2 of the specification and a translation thereof as requested by the Examiner.

Claims 1-4 were objected to for minor informalities. The claims have been amended as suggested in the outstanding Official Action. Accordingly, the Applicant respectfully requests the withdrawal of the objection to the claims.

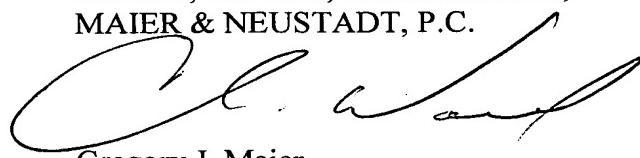
The Applicant submits that Claims 1-4 are in condition for allowance, as indicated on page 5 of the outstanding Official Action.

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Consequently, in view of the above discussion, it is respectfully submitted that the present application is in condition for formal allowance and an early and favorable reconsideration of this application is therefore requested.

Respectfully Submitted,

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## 29a-P9-20 SCM および EFM 用高分解能導電性探針の作製

Fabrication of high-spatial-resolution conductive probes for SCM and EFM

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【はじめに】 電子力顕微鏡(TEM)を用いた電気的測定には導電性カーネルバーが必要である。走査型キャッピングスコープ(SCM)や電気力顕微鏡(EFM)では、高い導電率を有しあつ良い空間分解能の電極が得られる金属性コートの探針が通常用いられている。SCMやEFMは長距離力である電気力を用いて測定を行うために、空間分解能はティップのごく先端の三각形形状だけではなく、先端附近のマクロな形状によっても影響を受ける。そこで、「電気的に見た」探針先端を小さくするために、金属を三角錐やティップの一面にのみコートした針を作製し、半導体チップのSCM測定を行なったところ、高空間分解能の測定を得たので報告する。

【実験・結果】 市販の三角錐のノンドープシリコンティップをUVおよびFIRで焼却した後、Ptを三角錐の一面にのみコートした。この探針を用いて、DRAMの財團のSCM測定を行った。図108度傾角で照らした領域を測定したものが図1、図2である。図2が通常SCM測定に用いる金属のCoCrコートの探針の測定結果、図1が今回考案した三角錐コートの探針の測定結果である。無い部分の暗い空き層がより明瞭にみえてわかる。なお当日は、EFM(SPM)の測定結果についても報告する。



図1 DRAMの断面 dC/dV 像 ( $10 \times 5 \mu\text{m}^2$ )



図2 CoCrコート探針の測定結果 ( $2 \times 1 \mu\text{m}^2$ )



図3 Ptコート探針の測定結果 ( $2 \times 1 \mu\text{m}^2$ )

## 29a-P9-21 多層カーボンナノチューブ探針の切断による先端形状と先鋒化

Cutting and sharpening of multiwalled carbon-nanotube probes

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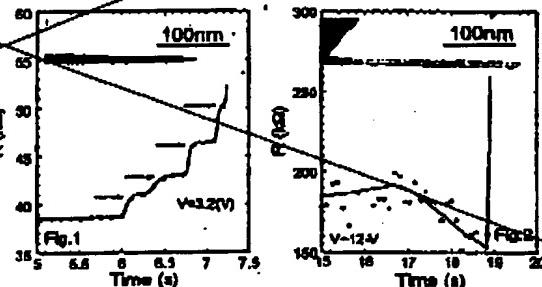
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はじめに 多層カーボンナノチューブ(CNT)を探針とする時、その高さと先端形状は高分解能観察には非常に重要である。本研究では、過剰電圧による CNT 切断時における CNT 先端の形状について検討した。

実験 電導性探針と電極の間に接続した CNT への印加電圧を徐々に増加する。印加電圧変化に対し電流の変動が現しくなった時電圧一定とし CNT が切れるまでの電圧の時間変化を測定した。実験は圧力  $2 \times 10^{-6}$  Pa 以下、室温の SEM 中で行った。

結果と統計 CNT と電極との接触抵抗が低い図1の場合、先端部は TEM 像のように徐々に細くなり、電圧 3.2V での抵抗の増加は微細化になる。これは、CNT の端部から一層ずつ層が削除することを反映している。一方、図2の接触抵抗が最も高い 100kΩ 以上の場合は、図1とは異なりその断面は急峻で先端が削いている。切断が始まる電圧は図1,2 何れの場合も  $\sim 80 \mu\text{A}$  程度とほぼ等しく過剰電圧でのみ CNT が切断されたと想われる。これより図2の場合は印加電圧が 12V と高く切断された場合に限らず、多少は電流が生じ切断面が急速になってしまったと考えられる。

結論 切断時の電流を制御し先端のみ先鋒化した理想的な探針製作に成功した。



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添付資料1

(1) "Lecture Manuscripts of 49th Applied Physics Relation Joint Lecture Meeting",  
March 2002, Shonan School Building in Tokai University, pp. 687

The following is an English translation of an extract of the above document.

A conductive cantilever is necessary for electrical measurement using interatomic  
5 forces microscope (AFM). For a scanning capacity microscope (SCM) and an electrical  
force microscope (EFM), a metal-coated probe having high conductivity and capable of  
obtaining a signal of good spatial resolution has been usually employed. Because SCM  
and EFM perform measurements using electrical force which is a long-distance force,  
spatial resolution may be influenced not only by a microscopic shape at an extreme edge of  
10 a chip but also by a macroscopic shape near the edge of the chip. In order to reduce the  
edge of the probe (in a macroscopic standpoint), the probe having one surface of a  
triangular pyramid shaped chip coated with metal has been designed. After the probe  
has actually formed and SCM measurement of a semiconductor device has been performed,  
images of high spatial resolution has been obtained.

15 After commercially available triangular pyramid shaped non-doped silicon chip has  
been processed using UV and hydrofluoric acid, one surface of the triangular pyramid  
shaped non-doped silicon chip is coated with Pt. The SCM measurement of a cross  
sectional surface of DRAM has been performed using this probe. Figs. 2 and 3 show  
the measurement results of the area surrounded by a white square shown in Fig. 1. Fig. 2  
20 shows the measurement result where a commercially available CoCr-coated probe usually  
used for the SCM measurement is employed, and Fig. 3 shows the measurement result  
where the probe having one surface of the triangular pyramid shaped chip coated with Pt,  
which is designed, this time is employed. It is found out that a black belt-shaped  
junction depletion layer can be seen clearly. On the day, the measurement results of  
25 EFM (SPoM) will be reported.